

Recent Results of $A_{LL}^{\pi^0}$ measurement at $\sqrt{s} = 510\text{GeV}$ at Mid-rapidity by PHENIX Experiment

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1. Motivation

- Spin sum rule: $\frac{1}{2} = \int_0^1 dx [\frac{1}{2} \sum_q (\Delta q + \Delta \bar{q}) (x, \mu^2) + \Delta g(x, \mu^2)] + L$

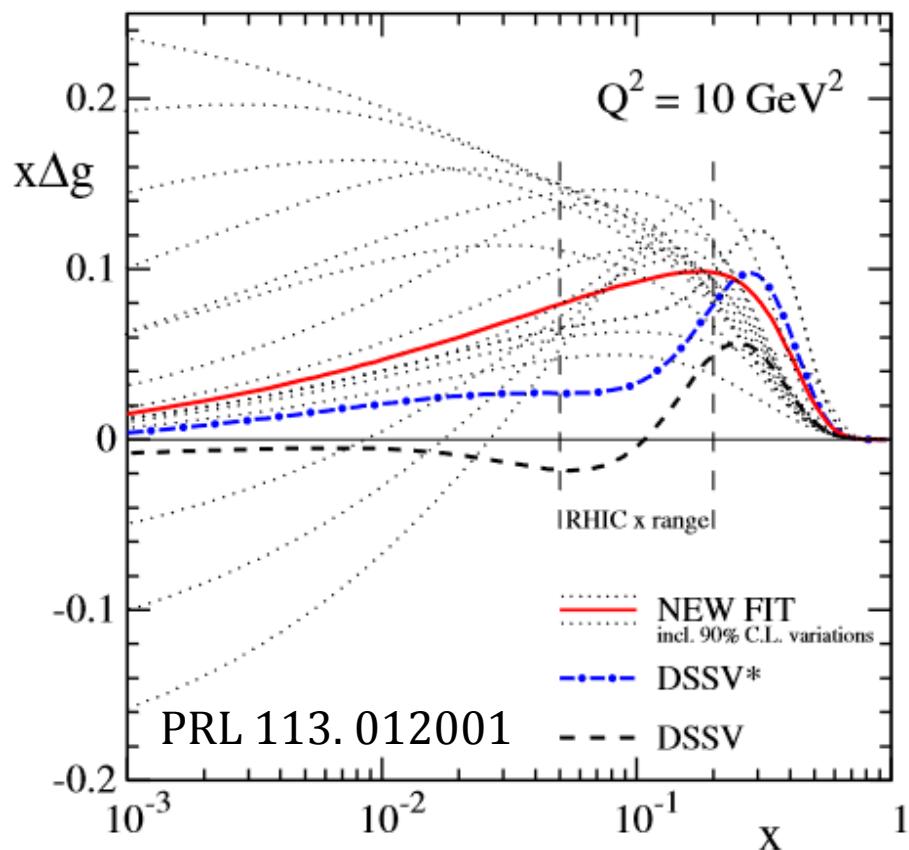
DIS experiment: quark contribution is only 25~35%.

Gluon polarization, $\Delta G = \int_0^1 dx \Delta g(x)$

- PP collision provide access to Δg through gg and qg scattering.

- $A_{LL}^{\pi^0}$ measurements give access to Δg

- $A_{LL}^{\pi^0}$ at higher $\sqrt{s} = 510\text{GeV}$ extends the sensitivity to Δg to lower Bjorken x.

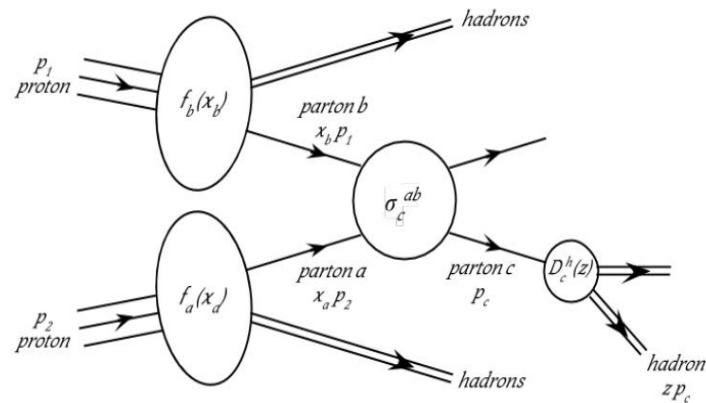
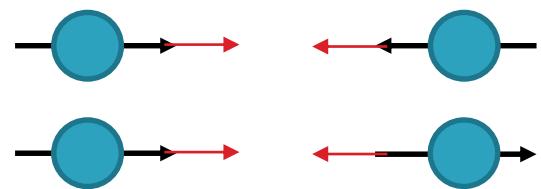


2. $A_{LL}^{\pi^0}$ and its interpretation

- $$A_{LL}^{\pi^0} = \frac{1}{P_B P_Y} \frac{\sigma_{++}^{\pi^0} - \sigma_{+-}^{\pi^0}}{\sigma_{++}^{\pi^0} + \sigma_{+-}^{\pi^0}}$$

$\sigma_{++}^{\pi^0}$: σ^{π^0} from same helicity proton collision.

$\sigma_{+-}^{\pi^0}$: σ^{π^0} from opposite helicity proton collision.



$\sigma^{f_a f_b \rightarrow f_c X}$: pQCD

$D_{f_c}^{\pi^0}$: $e^+ e^-$ experiment

- $$A_{LL}^{\pi^0} = \frac{\sigma_{++}^{\pi^0} - \sigma_{+-}^{\pi^0}}{\sigma_{++}^{\pi^0} + \sigma_{+-}^{\pi^0}} = \frac{\sum_{f_a, f_b, f_c} \Delta f_a \otimes \Delta f_b \otimes d\hat{\sigma}^{f_a f_b \rightarrow f_c X} \otimes D_{f_c}^{\pi^0}}{\sum_{f_a, f_b, f_c} f_a \otimes f_b \otimes \hat{\sigma}^{f_a f_b \rightarrow f_c X} \otimes D_{f_c}^{\pi^0}}$$

3. Longitudinal Spin Data

Year	\sqrt{s} (GeV)	$L(Pb^{-1})$	P(%)	FoM(P^4L)
2003	200	0.35	27	0.0019
2004	200	0.12	40	0.0031
2005	200	3.4	49	0.2
2006	200	7.5	57	0.79
2006	62.4	0.08	48	0.0042
2009	500	10	40	0.26
<u>2009</u>	<u>200</u>	<u>14</u>	<u>57</u>	<u>1.4</u>
2011	500	16.7	48	0.88
2012	510	30.03	52	2.2
<u>2013</u>	<u>510</u>	<u>150</u>	<u>55</u>	<u>14</u>

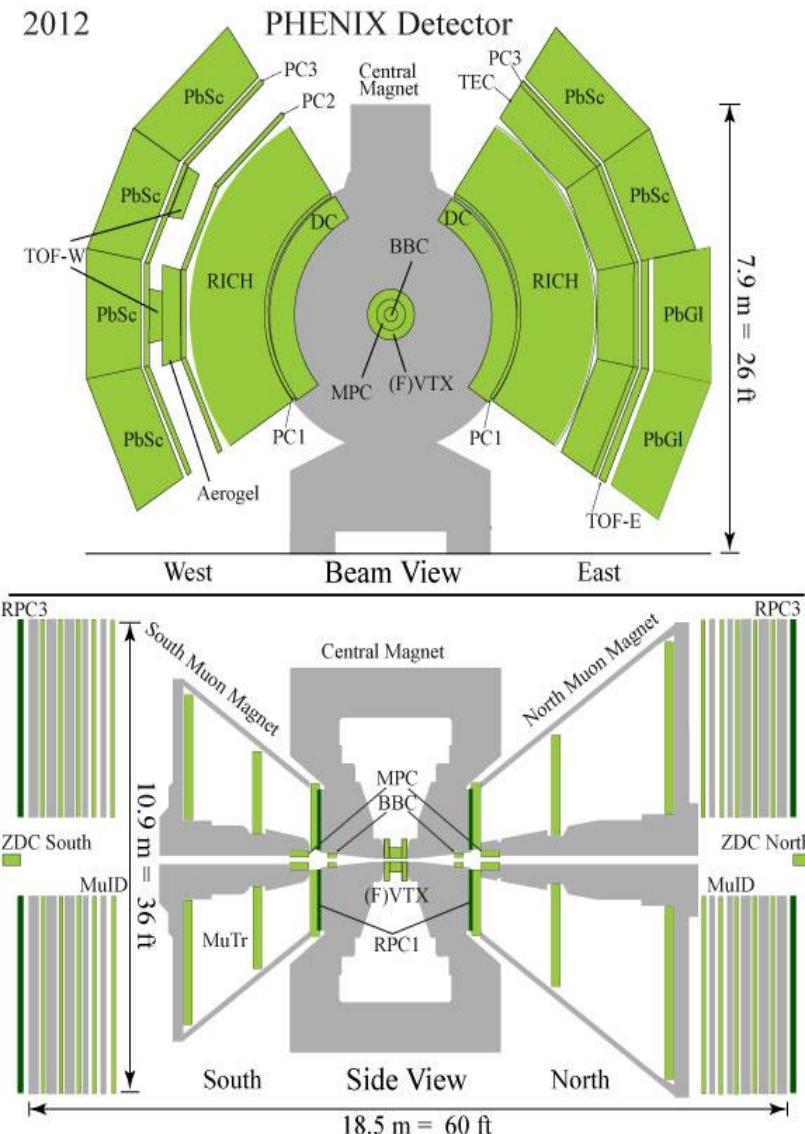
4. Introduction to PHENIX

Central arm: $|\eta| < 0.35$, $\Delta\theta = \frac{\pi}{2} \times 2$

- Tracking : Vertex detector, DC, PC
- PID : RICH
- EM calorimeter: PbSc and PbGl

Farward Arm:

- Minbias detector : BBC, ZDC
- Muon tracking and ID: MuTr, MuID
- EM calorimeter: MPC



5. Analysis Procedure

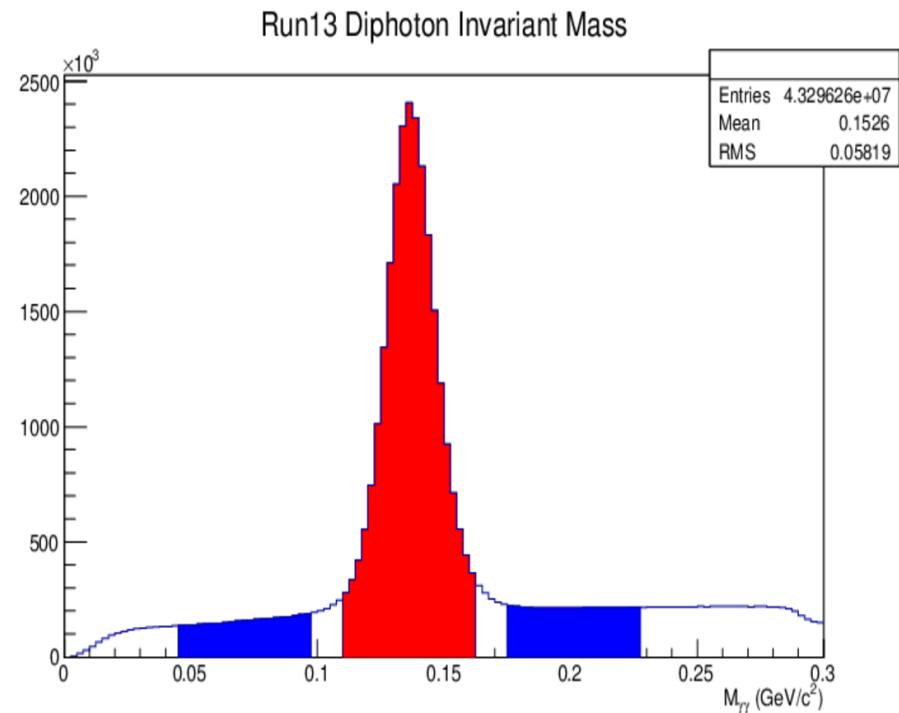
- Count yield of signal and side region.

$$\begin{aligned}
 \bullet A^{Peak(Side)}_{LL} &= \frac{1}{P_B P_Y} \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}} \\
 &= \frac{1}{P_B P_Y} \frac{\frac{N_{++}}{\varepsilon_{++} L_{++}} - \frac{N_{+-}}{\varepsilon_{+-} L_{+-}}}{\frac{N_{++}}{\varepsilon_{++} L_{++}} + \frac{N_{+-}}{\varepsilon_{+-} L_{+-}}} \\
 &= \frac{1}{P_B P_Y} \frac{N^{Peak(Side)}_{++} - R N^{Peak(Side)}_{+-}}{N^{Peak(Side)}_{++} + R N^{Peak(Side)}_{+-}},
 \end{aligned}$$

where $R = \frac{L_{++}}{L_{+-}}$. (source of syst.)

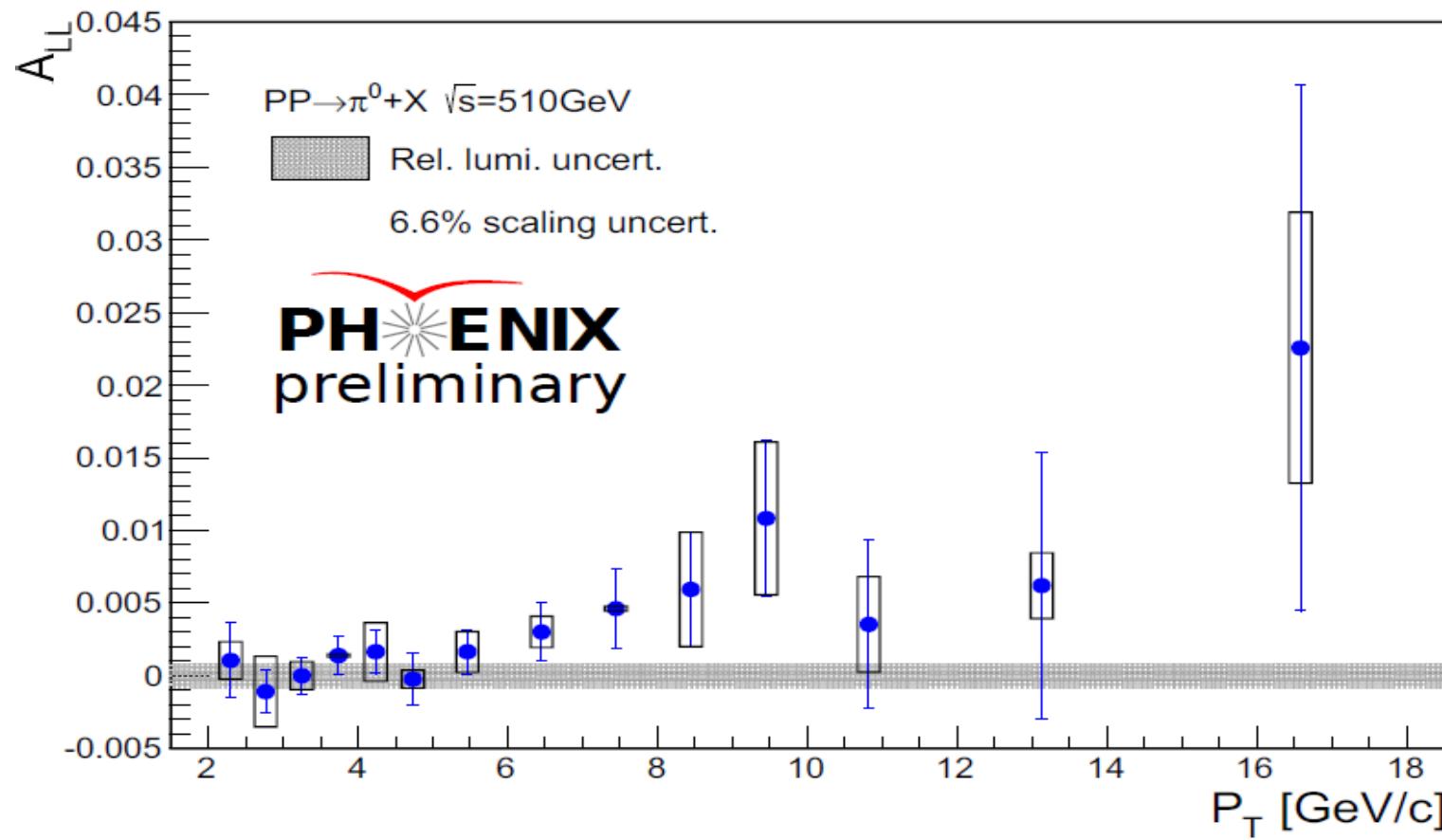
$$\bullet A_{LL}^{\pi^0} = \frac{A_{LL}^{Peak} - r A_{LL}^{Side}}{1 - r},$$

r = background fraction.

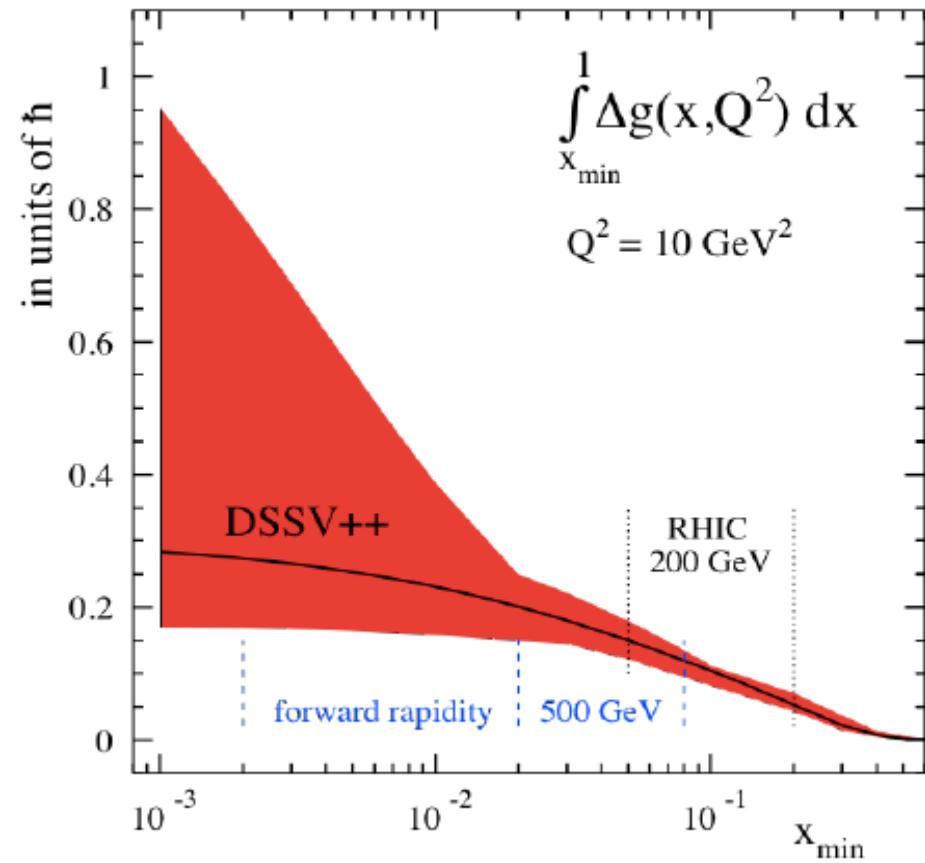
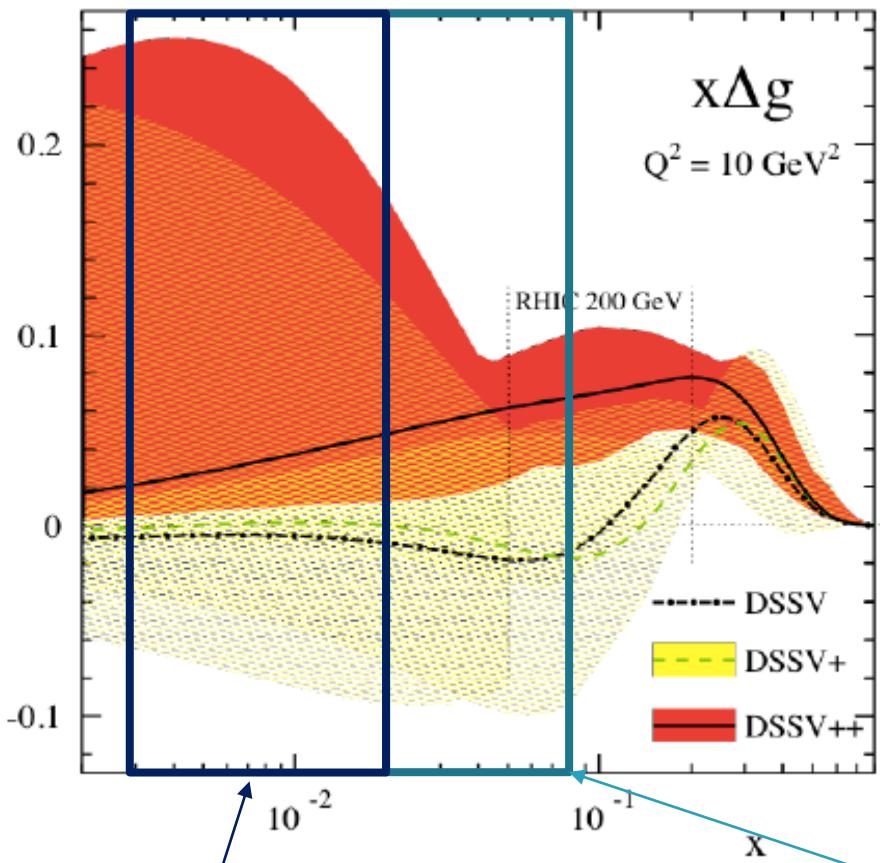


- ↑ Identifiable mass peak.
Large stat.
Various cuts to minimize uncert.

5. Preliminary Results



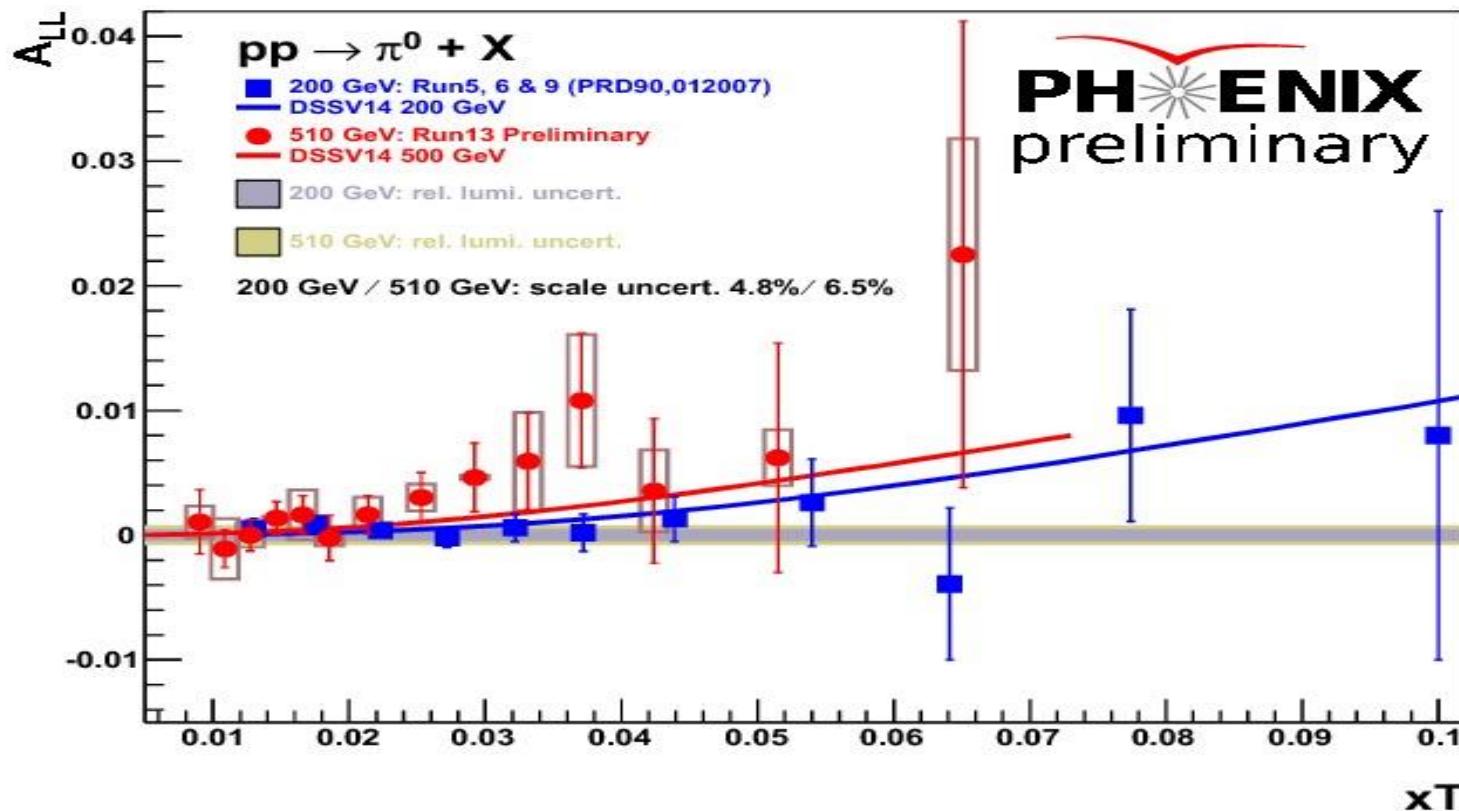
5. Preliminary Results - Expected Impact



510 GeV Region

with MPC : analysis ongoing with Run12 and Run13 data

5. Preliminary Results



- Scaling dependence isn't same for 200 GeV and 510 GeV result.
Both of data and theory support it. Evolution effect?

$x_T = \frac{2P_T}{\sqrt{s}}$: Poor man's version of the average x .

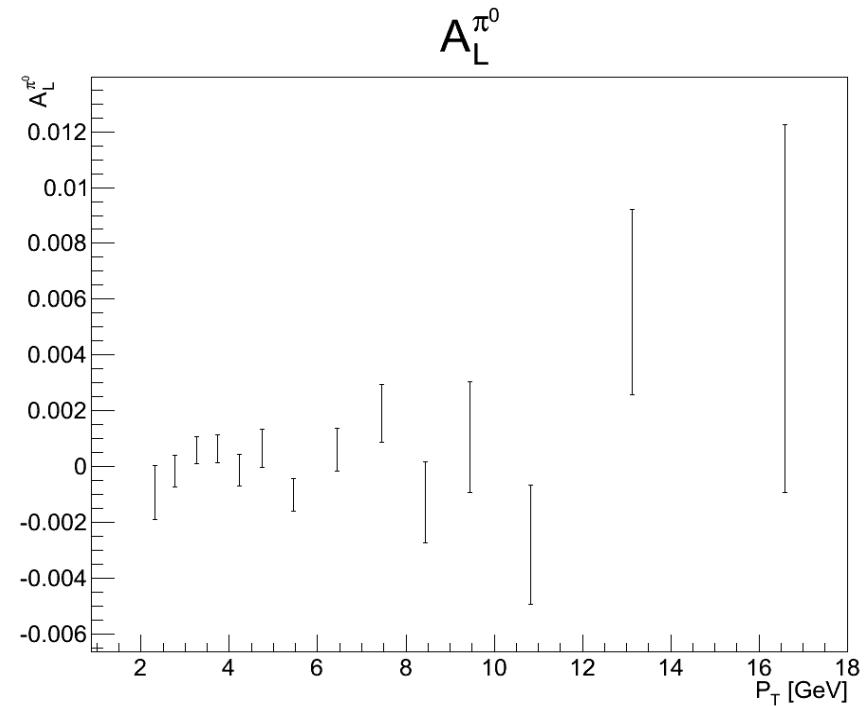
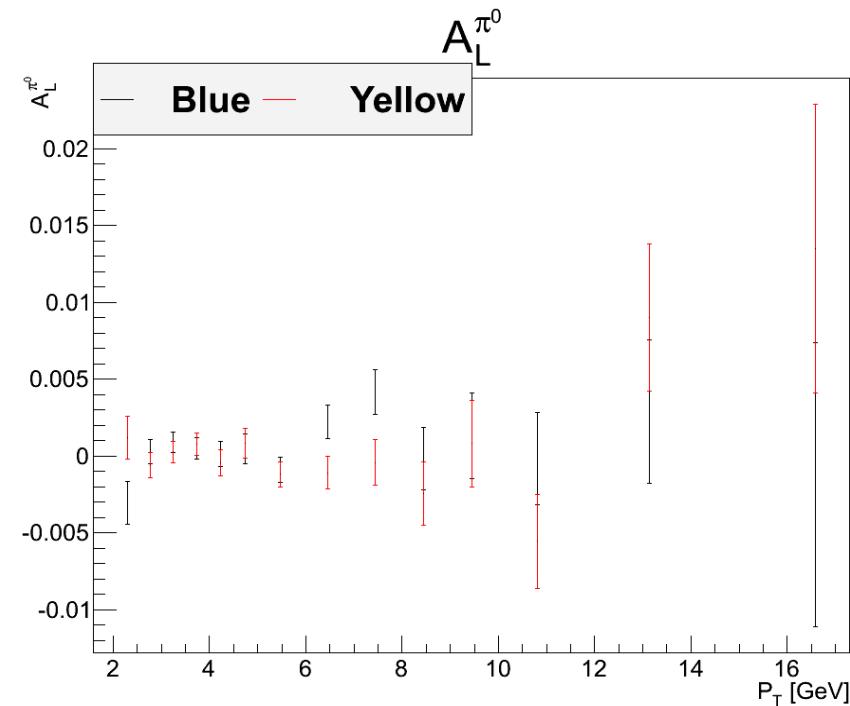
6. Summary

- Run13 pp 510GeV data has been taken and analyzed.
: Integrated Luminosity 150 pb^{-1} , Pol $\sim 56\%$
Preliminary result is released.
- Larger asymmetry was observed. (cf. Run09 $A_{LL}^{\pi^0}$ at $\sqrt{s} = 200 \text{ GeV}$)
- We hope the result help global analysis and constrain Δg .
- Analysis is ongoing for final result.
 - Smaller stat. and syst. uncert. will be achieved.

Back Up

Cross Check $A_L^{\pi^0}$

- Zero $A_L^{\pi^0}$ must be obtained.
∴ Parity invariant strong interaction.



Bunch Shuffling

- Validity check of stat. eq. and unknown syst. model independently.

